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Distributed Generation, Combined Heat and Power, and Micro-Cogeneration

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Topics

- Central Utilities
- Distributed Generation and CHP at Clemson
- Industrial Sized Cogeneration
- Micro-Cogeneration
  - » Control Strategies
  - » Results
  - » Targeted Opportunities
- Education/Research Collaboration

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Central Utilities

Average Yearly Energy Consumption

- 120,000,000 kWH Electrical Consumption
  - » Supplied by Duke Power (Duke Energy Corp.)
  - » Peak Summer Demand - 21 MW
- 400,000,000 lbs. Steam Consumption
  - » Primary Fuels – Coal & Natural Gas
  - » Emergency Fuel - No. 2 Fuel Oil
- 425,000,000,000 BTU Chilled Water Consumption
  - » 5,400 Tons Electric Centrifugal, 1,000 Tons Absorption - CEF
  - » 2,250 Tons Electric Centrifugal - East Campus Plant

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Distributed Generation

Existing Assets (10,230 kW)

- SOLAR Taurus 60 Gas Turbine (4800 kW)
  - » Inlet Air Cooling + 615kW in Summer
- SOLAR Mercury 50 Gas Turbine (3800 kW)
- Caterpillar Diesel IC Engine (750 kW)
- Caterpillar Diesel IC Engine (300 kW)
- Kohler Diesel IC Engine (550 kW)
- Capstone Microturbine (30 kW)

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Distributed Generation - CHP

SOLAR Taurus 60 Gas Turbine Generator

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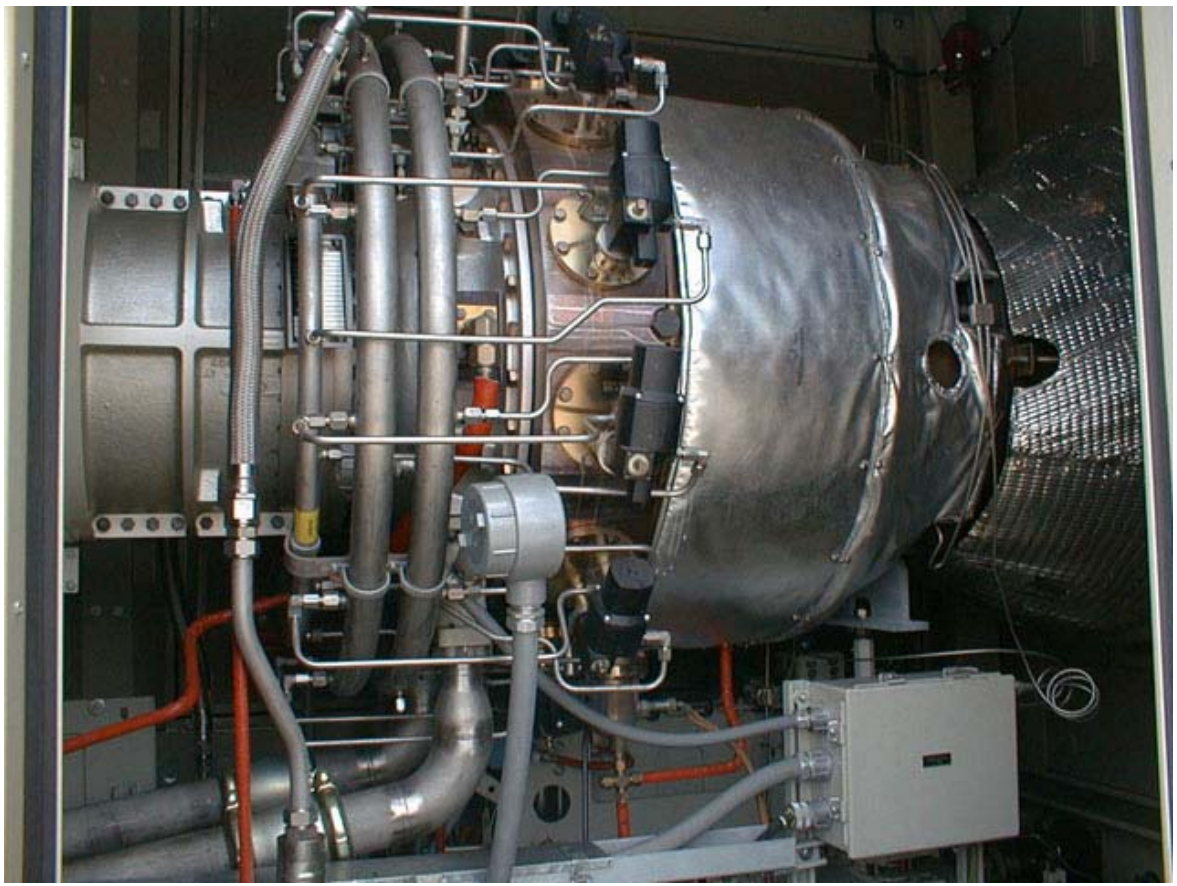
Distributed Generation - CHP

SOLAR Taurus 60 Gas Turbine Generator



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Distributed Generation - CHP

ERI Heat Recovery Boiler

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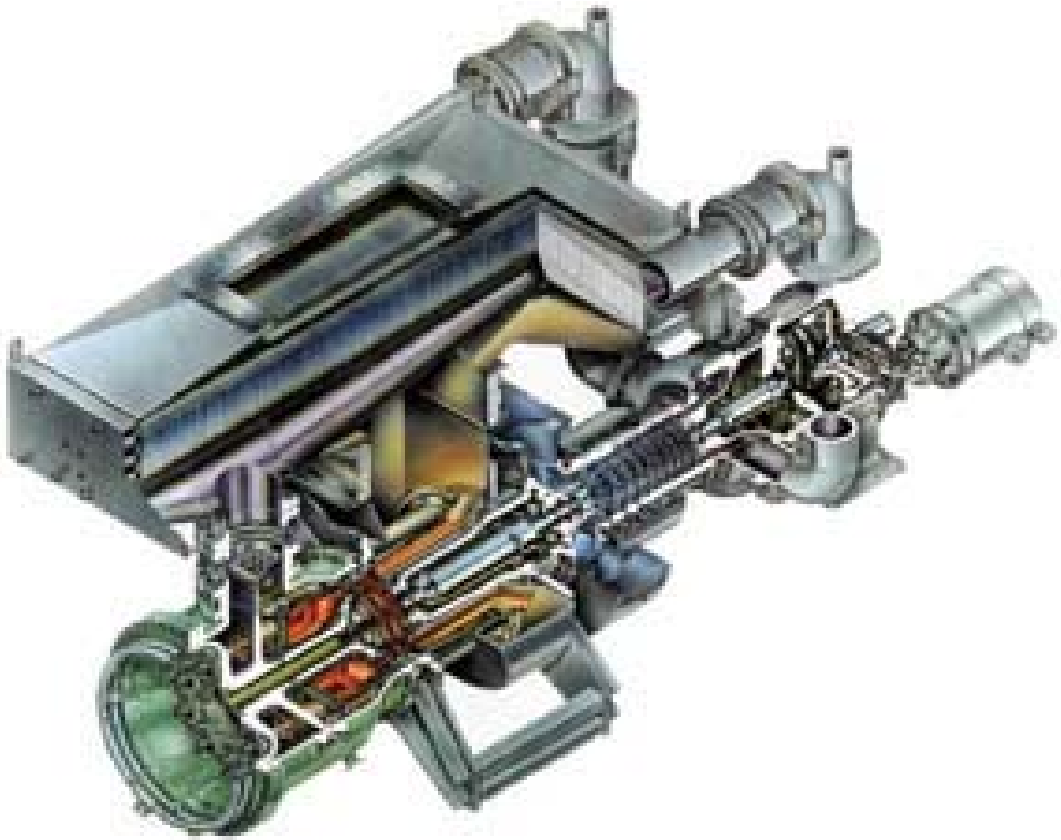
Distributed Generation

SOLAR Mercury 50 Advanced Gas Turbine



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Distributed Generation

SOLAR Mercury 50 Advanced Gas Turbine

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Distributed Generation

Ag/Bio-Tech Emergency Generator

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Distributed Generation

Ag/Bio-Tech Emergency Generator

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Distributed Generation

CEF Emergency Generator

- 300 kW Diesel Generator to Start Taurus 60
- Original Design Uses Automatic Transfer Switches
- Full Capacity Paralleling Gear Upgrade Will Be Added for a Total Cost of $70,000
  - » Estimated Savings of up to $20,000 per Year
  - » Limited Runtime (180 hrs/yr.)
  - » Improved Testing, Maintenance, and Operation Due to Generation at Full Load

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Distributed Generation

CEF Emergency Generator

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Distributed Generation

CEF Emergency Generator

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Capstone Microturbine CHP

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Capstone Microturbine CHP

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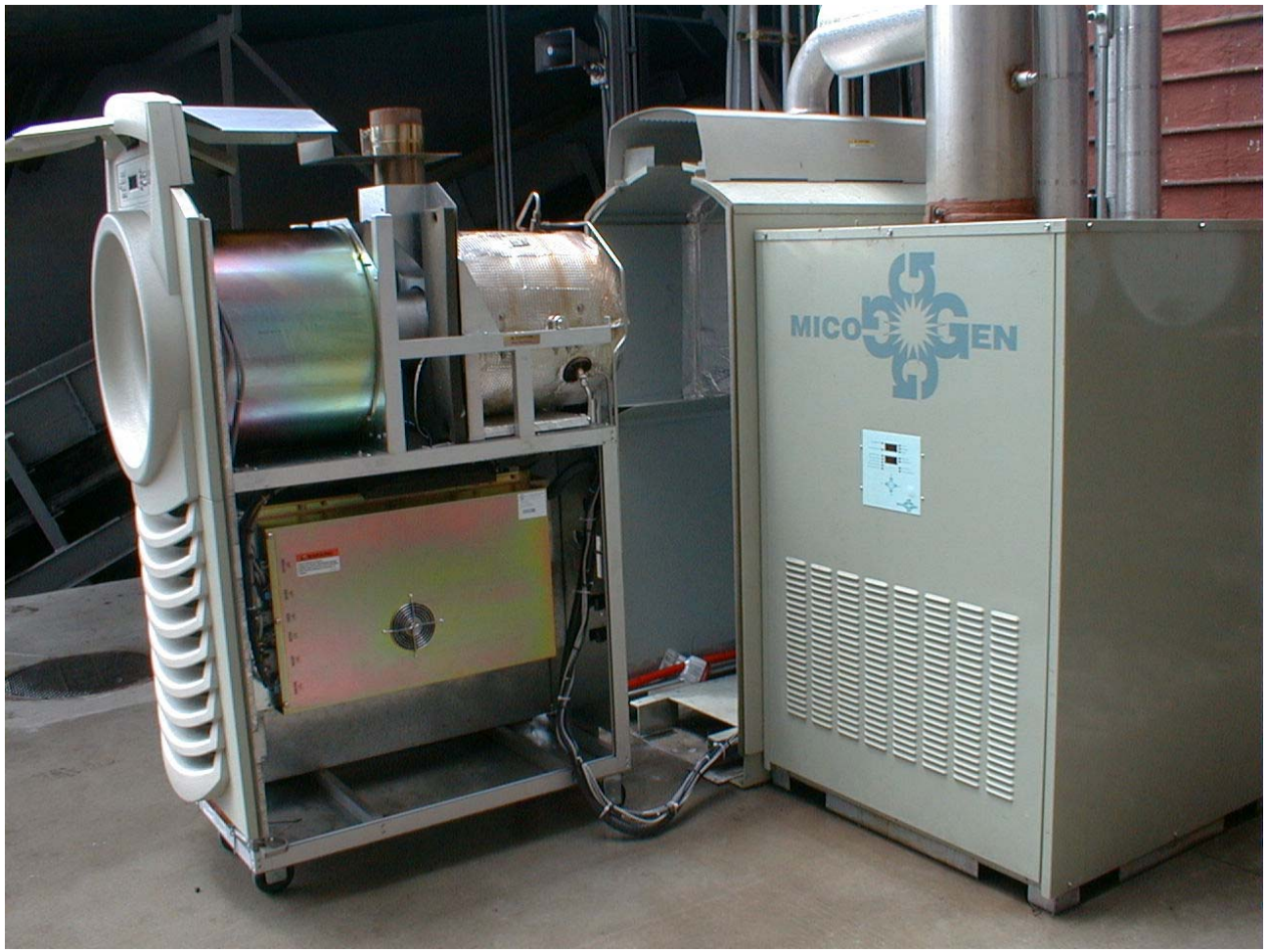
Distributed Generation

Capstone Microturbine CHP



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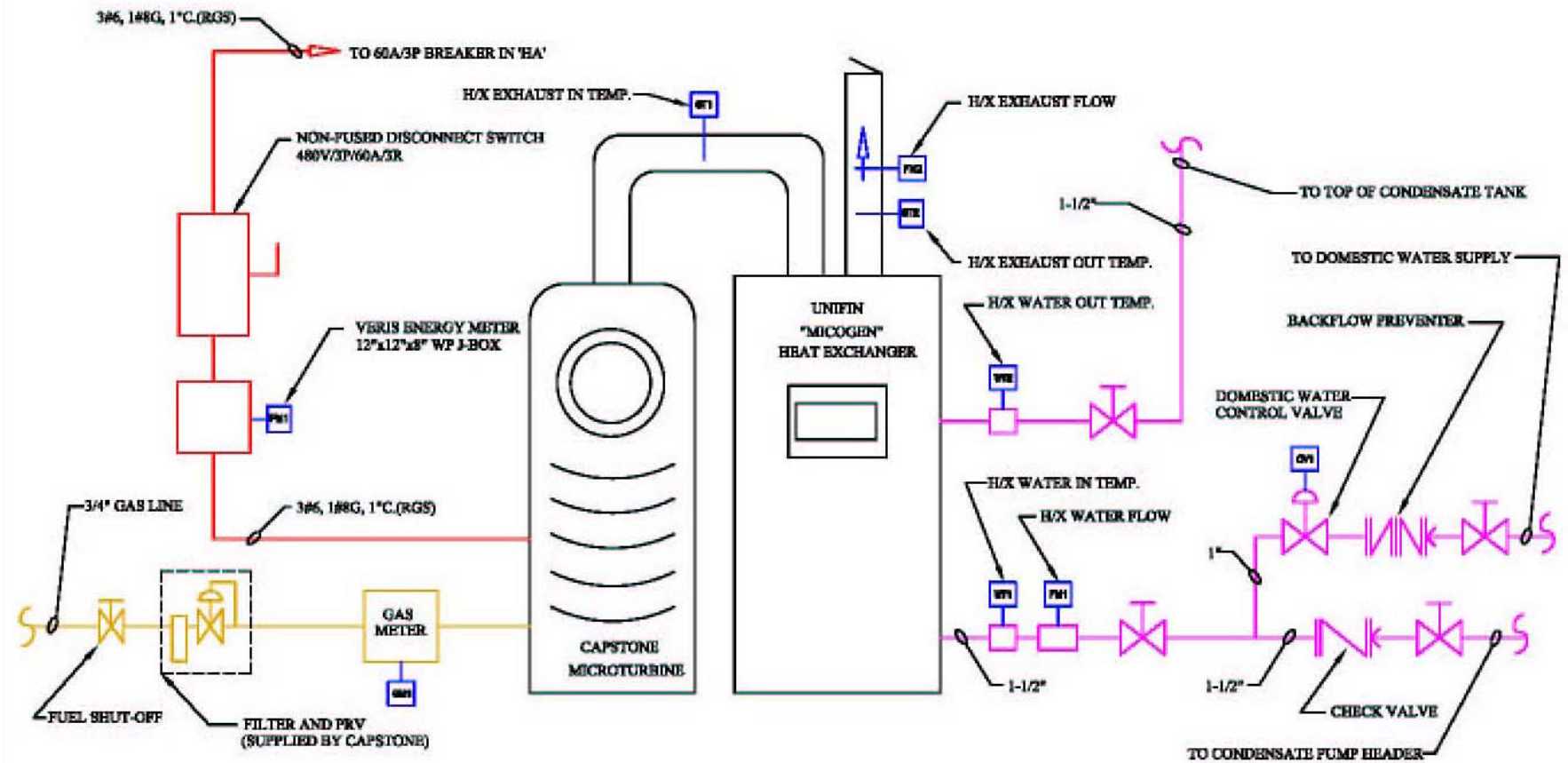
Micro-Cogeneration



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Micro-Cogeneration

- Controls ensure maximum flexibility
  - » Water flow from 6 to 30 GPM
  - » Entering water temperature from 55F to 145F
- Wide variation in system efficiency
  - » 63% at OA=20F and EWT=135F
  - » 92% at OA=85F and EWT=65F
- Highest system efficiency may not be best
  - » Electric cost usually > Heat Costs
- “Plug-and Play” difficult to implement and could produce disappointing results

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Micro-Cogeneration

- Installed Cost of $47,300 (estimated retail)
  - » Clemson Cost significantly lower due to generous contributions from Capstone and Johnson Controls, in-house engineering, and in-house installation.
- Maintenance costs to date - $2,100 (14,500 hours)
- Availability good. Two engine failures related to bearing failures (replaced under warranty). Possibly related to coal dust. Filter service interval reduced.
- Projected simple payback at average SC commercial rates ($0.063/kWH & $0.65/Therm) in 5.2 years
- Projected simple payback at average CA commercial rates ($0.11/kWH & $0.62/Therm) in 2.5 years

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Micro-Cogeneration

- Emissions generally 50%-60% of published
  - » NOx virtually undetectable at elevated ambient temperatures and 5 ppm at ISO.
  - » CO – 32 ppm (ISO)
  - » UHC – 6 ppm (ISO)
- Permitted as an insignificant source (Title V)
- Noise tends to be concentrated at specific frequencies and some resonances noticed at lower power (lower turbine speed).
- A 4-20ma external kW setpoint would allow thermal load following.

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Educational/Research Opportunities

- Existing Metering and Monitoring Capability
- Addition of Metering/Monitoring for a Specific Application or Condition
- Operation of Generation at Specific Given Conditions
- Campus Becomes a Real-Time Laboratory of an Actual Distribution System.
  - » Data Collection Through Ethernet/Internet at Remote Sites
  - » Siting of DG Offerings From Utilities or Energy Services Companies (ESCO's) for Commercialization Testing
  - » Modification of Distribution System to Accommodate Specific Research Conditions
- Student Education

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Educational/Research Opportunities

- Energy Systems Laboratory
  - Promote collaboration between research, education, industry, and operations.
  - 8,000 square foot program space.
  - Establish partnerships with industry, government, and institutions to advance the relevancy of a Clemson education and fulfill the mission of public service.

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Educational/Research Opportunities

DISTRIBUTED ENERGY ROADSHOW
Atlanta Regional DOE

ABB

STEAM BEST PRACTICES
Alliance to Save Energy/DOE

Capstone

POWER SYSTEM 2003 CONFERENCE
DG and Advanced Metering

SCE&G
A SCANA COMPANY

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Electric Power Research Association

Questions?